



SOLVING PROBLEMS

*There is no such thing as applied sciences,
only applications of science.*

Louis Pasteur, 1872

Input Before Action

ON GYPSY MOTH INVASION

GYPSY MOTHS ARE NOT NATIVE TO WISCONSIN, BUT IN THE EARLY 1990S THEY SHOWED UP IN THE SOUTHERN UNIT OF THE KETTLE MORaine STATE FOREST.

This area is both the largest tract and one of the most heavily used forests in southeast Wisconsin. Hiking and camping are popular activities and the forest is widely known for offering some of the best mountain biking opportunities in the Midwest. If left unchecked, gypsy moths can defoliate hardwood forests and cause significant mortality, especially among oaks and other preferred trees.

Because the Kettle Moraine State Forest is an oak-dominated forest that includes many old and vulnerable white oaks, foresters knew they would have to do something to prevent defoliation of the trees. In the short term, defoliation can destroy the aesthetics of the forest. In the long run, defoliation can stress the trees making them vulnerable to mortality from other factors like drought or insects. Devastation of the forest by moths may have a negative effect on the experience of visitors, whether they come for a long vacation or a part-day outing. Although forest visitors may find gypsy moth outbreaks distressing, many people find management techniques (e.g., cutting trees or spraying pesticides) more distressing. It was clear that forestry staff needed more information to help them decide how best to address the gypsy moth problem.

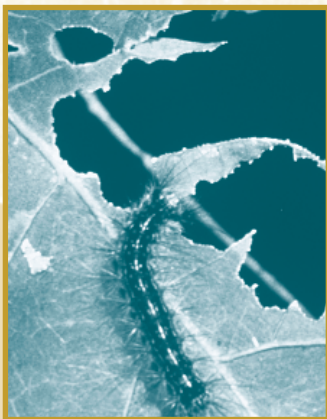
To address this issue, Andrea Diss, from the Division of Forestry, contacted Jordan Petchenik, a Science Services sociologist. Together they discussed research options for a project evaluating public response to gypsy moth control, and decided a focus group approach would be the best way to find answers to their questions. Through further consultation with Forestry staff, five user groups were identified for focus group discussions:

1. mountain bikers,
2. overnight campers,
3. day users (e.g., picnickers and hikers),
4. horseback riders, and
5. homeowners (within the boundaries or three miles of the state forest).

During the discussions, Jordan asked questions regarding various topics, such as:

- What is your recent experience with the forest and what attracts you to it?
- What is your current awareness and experience with gypsy moths?

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input before action

- What is your tolerance for tree defoliation, tree mortality, and moth nuisance?
- What would be your preferred method of moth control?
- What is your acceptance of aerial spraying and pesticides in general?
- What would be the possible effects of a moth outbreak on your future visits to the forest?
- What is the importance of moth suppression relative to other management issues within the Southern Unit of Kettle Moraine State Forest?

So what did Jordan find? Because each user group is different, there was only moderate consistency in the findings. For example, caterpillar frass (excrement) on picnic tables might be a concern to picnickers, whereas mountain bikers riding past these tables might not care. During the discussions, participants compiled a general list of issues and concerns related to the forest. When gypsy moths were prioritized within that list, the problem was listed as a top priority! Clearly, users want to see this problem addressed in the Kettle Moraine State Forest.

Participants of all five user groups held the belief that gypsy moths are a serious threat to the forest and that a management plan is essential. Although they were unclear about how moth activity would affect their visits to the forest, participants expressed concern about defoliation and declared themselves unwilling to accept moth-induced tree mortality. Of the five approaches discussed for moth control, aerial sprays of *Bacillus thuringiensis* var. *kurstak* (Btk) was the most preferred. Btk is a bacterium that occurs naturally in the soil. Btk kills caterpillars that ingest the bacterium within a week of its application. Participants did express concern about potential health consequences from aerial sprays or any pesticide use, and they requested that advance warning and information be given prior to any application.

The uniqueness of this study and the immediate usefulness of the information make this project very important. Jordan and Andrea believe it is wise to be pro-active and ask for public input at the *beginning* rather than asking people to react after a management mechanism has already been put in place. Seeking information from user groups is a critical initial step when developing a management plan and Science Services staff has demonstrated this to be a model process. It is very helpful that the participants consider a moth suppression plan essential. With the knowledge gained through the focus groups, the department can now proceed to address the gypsy moth problem with a win-win approach. ●



The Science of **RESTORING DEVIL'S LAKE**

HAVE YOU EVER TAKEN YOUR FAMILY TO A SPECTACULARLY BEAUTIFUL LAKE, SPENT THE AFTERNOON CHASING MINNOWS WITH THE KIDS IN THE SHALLOWS, SWIMMING OUT INTO THE DEEPER WATERS

to locate the cold patches with the teens, enjoying a picnic and lying in the sun, only to discover that you and the kids suffer from swimmer's itch for days to follow? Such scenarios tend to put a damper on family outings and enjoyment of some of our state parks and recreational lakes.

Because of experiences like these, local residents in the Baraboo area are excited about a project to attack the problem of swimmer's itch in Devil's Lake in an ecologically safe way. With as many as 1.5 million daily visitors recorded each year, Devil's Lake State Park is the most heavily used state park in Wisconsin. That makes the restoration of Devil's Lake by bottom water withdrawal a very visible and important project.

In the late 1970s, park staff and local residents noticed increased algae blooms in the late summer contributing to a decline in water clarity. This was particularly alarming since Devil's Lake was known for its exceptional water quality and clarity. The culprit was clear. Four resorts and over 60 cottages lined the lake earlier in the century causing septic leachate to enter the lake. In addition, excess nutrients (most notably phosphorus) entered the lake from the late 1970s through the early 1980s from a broken sewer main in the park. In the mid-1980s, park staff came to Science Services to ask for help in dealing with the water quality problem. Consequently, a team of researchers addressed all aspects of the lake's ecological issues and assessed how phosphorus cycled in the lake. They found that because the lake has no outlet, phosphorus is able to build up in the sediments of the lake. The excess nutrients in the lake result in longer and more intense algae blooms leading to a decrease in water clarity and eventually a change in lake vegetation.

During the 1990s Dick Lathrop, a Science Services limnologist, conducted a study to show that withdrawal of nutrient-rich water near the bottom sediments could work as a restoration technique for Devil's Lake. Dick's belief that the lake should be crystal clear, without algae problems, helped convince others that the lake needed restoring to its pre-settlement levels of low fertility. As a result, a committee of local citizens and DNR staff began developing a lake management plan. When future lake management projects began to materialize, one thing became clear, Devil's Lake is a jewel.

Reducing the availability of phosphorus causing excessive algae growths would reduce the incidence of swimmer's itch, lower fish mercury levels,

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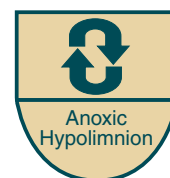


science of restoring

and enhance the cold-water fishery in the lake. In 2000, Dick went to an annual meeting of the Friends of Devil's Lake State Park and presented the idea for this project and the group agreed to sponsor it. Grants totaling \$310,000 from the state Lake Protection Fund, the U.S. Environmental Protection Agency (EPA), Friends of State Parks, and Friends of Devil's Lake have been used for installation of the bottom water withdrawal system. This project has been so well received that the EPA State Lake Protection Grant application was ranked the highest of all projects submitted for 2001!

The project depends on the installation of a 5,500-foot long, 20-inch diameter siphon pipe to draw water off the bottom of the lake at its deepest point. During summer stratification, the colder water at the bottom of the lake loses its oxygen and the sediment-bound phosphorus is released into the overlying water. Phosphorus builds up in the bottom waters of the lake from late summer through early fall, until the lake surface waters cool enough to allow complete mixing of the water column. The phosphorus is then taken up and stored by algae for future use. With the bottom water withdrawal project, we are removing the phosphorus-rich water from the bottom of the lake *before* the water has a chance to mix. The water siphoned from the bottom of the lake is discharged into an intermittent stream that drains into the Baraboo River. The discharge from the lake represents less than 0.1% of the total nutrient load into the river. Clean runoff water (from snowmelt and spring rains) that flows in this same intermittent stream will be diverted into the lake to replace the withdrawn water. Conveniently, a diversion system was originally built in the late 1800s to augment lake levels during periods of drought. It has not been used since around 1960, but it is currently in place and being refurbished for this project. Water samples are collected from the outlet of the siphon pipe and are sent to the State Laboratory of Hygiene for analysis. An automatic sampler takes the samples every eight hours. Staff members from the DNR's South Central Region are also collecting water quality data to help determine how the lake is responding to the restoration project.

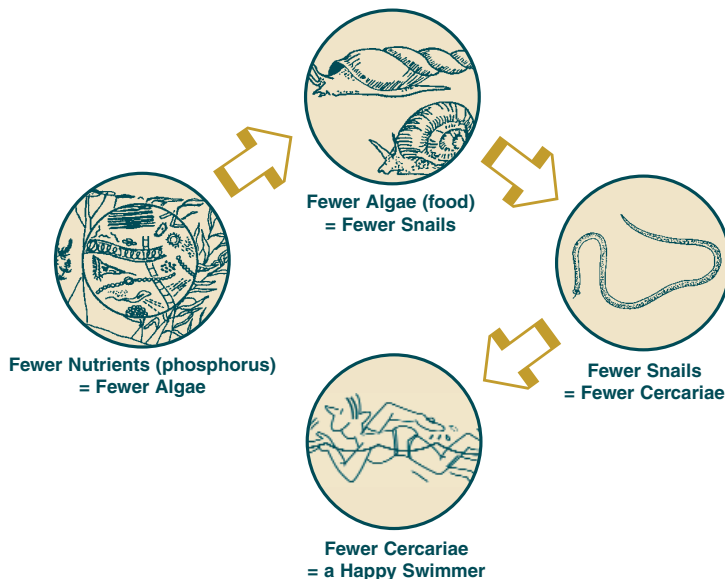
It is no easy task to set a 50-ton pipe in a lake. Concrete collars weighing 320 pounds each were bolted onto the pipe every 12 feet. A barge pulled the intake end of the pipe to the deepest part of the lake while the pipe was pushed from shore. It took a week and a half to float 4,200 feet of pipe in place on the lake surface before it was sunk. Two fire trucks filled the pipe with lake surface water to sink it slowly. Once the pipe was on the bottom of the lake, the land portion of the pipe leading to the discharge was trenched. The system is currently running well. A lot of work



Withdrawing the bottom water of Devils Lake relies on its ecology. In late summer the lake is stratified, trapping the nutrient-rich water on the bottom (anoxic hypolimnion). Installation of a siphon will remove the nutrient-rich water before it has a chance to mix in the lake during the fall.



High nutrient levels of phosphorus increase the amount of plant material growing on the bottom of the lake. Because snails eat the excess plant material, it allows the population to explode. The snails act as hosts to the parasite *Cercariae* that causes "swimmers itch". In short, excess nutrients cause higher plant growth, which causes more snails and allows for a greater chance of getting "swimmers itch". The graphic at right illustrates what happens when this cycle is altered by **not** allowing high nutrient levels in the lake.



was involved installing the siphon pipe during the summer of 2002, but now Dick just has to go there once or twice a week, from early September through mid-October each year to monitor the phosphorus removal.

The contractor that did the installation won an award for "Project of Distinction for Environmental Projects" from the Wisconsin Associated Builders and Contractors, Inc. Now the long-term project of restoring the lake begins. The bottom water removal system will only run in September and October, as this is the time the phosphorus accumulates at the bottom before the lake mixes. Once installed, the siphon system costs almost nothing to use. The bottom withdrawal project is expected to continue for up to 15 years.

Initial reports say the project is removing a lot of nutrients from the lake. In the first year alone, about a half-ton of phosphorus was removed by the siphon. Dick has high hopes for returning the lake to the way it was in the late 1800s before excess nutrients were added. External sources for nutrients in the lake are no longer high. Only four cottages are present now, and no resorts. His wish is to "make a lasting difference that future generations will enjoy". In the end, park staff and visitors will have a cleaner lake with easier management.

In addition to having a huge impact on the water quality of Devil's Lake, this project can serve as a model for the restoration of other lakes in a similar situation. This method has never been tried at this scale on a seepage lake (a lake without an outlet) anywhere in the world! The data regarding the effectiveness of this method could energize lake restoration efforts throughout the country. ●

Repairing environmental damage...

Environmental restoration projects are sometimes necessary when fish, wildlife, or related habitats are damaged or destroyed. The long-term evaluation and restoration of surface and groundwater quality also sometimes requires specific remediation projects. The Environmental Damage Compensation program administered by Science Services provides funds for some of these efforts.

"State law provides several mechanisms by which the DNR can require a remedy for the adverse environmental effects of illegal pollution," explains program coordinator Carla Wright. When a person violates a state pollution law and causes significant damage to the environment, restoration costs (e.g., costs for the physical repair of a site or for mitigating impacts such as payment for dead fish or wildlife) are sometimes obtained as part of the remedy in an



enforcement action. Settlements in lieu of court actions can also result. Money from these settlements is deposited in the Environmental Damage Compensation account, which is supplemented with a small annual appropriation.

The amount of money from litigated settlements varies. Although one of the highest settlements exceeded \$200,000, most awards have been substantially lower.

An agency Manual Code provides procedures for developing and deciding specific restoration projects. Science Services solicits new projects from department staff annually and funds projects on a competitive basis. According to Wright, "staff often use funds from the Environmental

Damage Compensation account to leverage other resources. Sometimes the availability of EDC monies is what allows a project to move forward."

Environmental Damage Compensation projects funded during the 2001-2003 biennium.

Project	DNR Region	Award
Hustisford boat landing and habitat restoration	SCR	\$10,310
Data collection for removal of Genesee Creek dam	SER	\$22,405
Restoration of LaValle dam lake bed area	SCR	\$35,000
Removal of Linen Mill dam	SCR	\$12,500
Kewaunee Marsh arsenic containment	NER	\$37,800
Removal of abandoned houseboat on St. Croix River	WCR	\$4,500
Re-routing of Silver Creek to protect Silver Lake	NER	\$40,000
Rip-rap of Wisconsin River train trestle abutment	SCR	\$3,000
Removal of Johnsonville dam	SER	\$17,000
Removal of Beers Creek dam	SCR	\$14,627
Shore protection at Rock County's Murwin Park	SCR	\$25,000
Steiner Branch stream restoration	SCR	\$7,800
Closure of Solid Waste Recovery System landfill	NOR	\$43,365
Clean up of dump sites on Branch River	NER	\$15,000
Total		\$288,305

Measuring RIPARIAN RUNOFF

RIPARIAN AREAS ARE LOCATED ALONG STREAMS, RIVERS, LAKES, OR OTHER BODIES OF WATER. THEY ARE IMPORTANT FOR MANY TYPES OF VEGETATION, FISH, AND WILDLIFE.

As more and more people are building homes along the shores of our lakes, the visual changes in the landscape raise questions about the impacts of lakeshore development on the quality of our water. Excessive amounts of nutrients that enter our lakes leads to eutrophication (accelerated plant growth). Sometimes plant growth may be in the form of nuisance algae that “bloom,” turning the water pea green and sometimes even causing fish kills.

Some counties have implemented zoning standards for lakeshore development. These standards determine what percentage of lakeshore property can be built on compared to the percentage that must be left undisturbed.

Previously, research had been done on the effects of agricultural buffers, but little research has been done in Wisconsin on other shoreline issues like the potential runoff (i.e. the water that runs off the land surface during and after a rain) from lawns on developed sites. As zoning ordinances come up for review, county staff and zoning officials want strong evidence that lawns are a source of excess nutrient input into lakes. The rapid increase of development in northern Wisconsin and letters received from that part of the state supporting more research on lakes led to the creation of a cooperative study with the U.S. Geological Survey called “The Effects of Shoreline Development on Water Quality.” Steve Greb, research hydrologist and project manager, indicates that the study is currently expanding to encompass the whole state and not just the northern region.

This project is specifically designed to examine differences in runoff *volume* (i.e. amount of water) and runoff *nutrient concentrations* entering lakes from developed lawn sites compared to forested or natural areas. The study is broken down into two phases. The first phase started in the summer of 2000 and was completed in the summer of 2002. That phase focused on four lakes in Forest and Vilas counties. The second phase, which started in the fall of 2002, is focusing on how well riparian buffers capture runoff. The sites for the second phase of the study are statewide. Researchers will complete this phase of the study in the fall of 2004.

In the first phase of the study, researchers installed plastic sheet flow collectors (e.g., lawn edging) at the bottom of hills coming down to the lake from lawn or forested areas. The sheet flow collectors funnel collected stormwater through a pipe into a bottle where the volume was measured. At the same time they also measured the total volume of

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riparian runoff

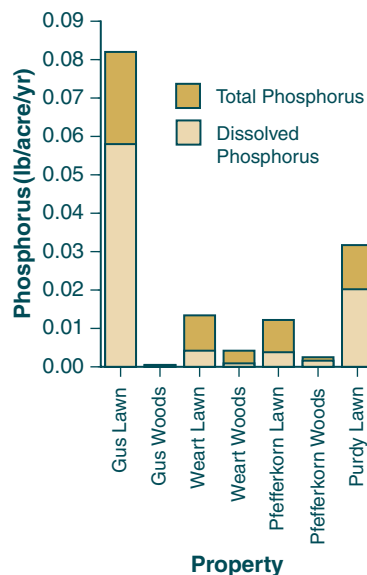
rainfall so they could compare the runoff volume to the total volume of rainfall. Additionally, nutrient concentrations (e.g., nitrogen and phosphorus) were determined in the runoff.

In the second phase of the study, researchers are using electronic moisture sensors to monitor naturally occurring runoff from rainfall. They are also physically dumping water on the sites and monitoring runoff down the hill. By doing this they hope to discover what length of riparian buffer is required for infiltration of the runoff that may occur from gutter downspouts. A riparian buffer refers to an area with diverse vegetation as opposed to a monoculture lawn. The area could be unmowed grassy or forested buffer. Currently, the recommendation is to maintain vegetative buffer at least 30 feet from the watermark. This research will strengthen the validity of the 30-foot buffer zone that has been prescribed.

Up to this point samples have been collected from a number of storms over the past two years. Preliminary results indicate that there is more runoff volume from lawns than wooded areas. However, preliminary results did not find significant differences in runoff nutrient concentrations from lawns compared to forested sites. To interpret what these results indicate, Greb and his colleagues looked at the *nutrient load* entering the lakes. To calculate nutrient load (reported as pounds per acre per year) the runoff volume is multiplied by the runoff nutrient concentration. What they found was that the nutrient loads for nitrogen and phosphorus from lawns were much higher than the loads from forested areas. On average, the phosphorus load was *eight times higher* coming from a lawn than from a forested area. Since preliminary results did not find significant differences in runoff nutrient concentrations from lawns compared to forested sites, researchers concluded that the difference is in the *volume* of water, not the *concentration* within the water.

These preliminary findings reveal to us that an effort must be focused on reducing the volume of water running into the lake, more so than reducing the amount of nutrients in that water. One way of reducing the volume of water is increasing the size of the riparian buffer zone that can absorb the water. This is a very complicated issue. At the county zoning level, it is hard to tell landowners what portion of their lot can be opened up as a view corridor to the lake. The issue also raises concerns for private property rights. The DNR sets state standards on which counties base their ordinances. The impacts will ultimately reach the landowners, who will benefit from their own best management of their lakeshore property. Good science leads to smart management of the resources, and this information will be used to help protect our lakes. ●

Phosphorus nutrient loads from lawns and forested areas.





Of **DAMS AND FISHES**

THE DNR HAS PLACED A HIGH PRIORITY ON RETURNING WISCONSIN'S RIVERS AND STREAMS TO A CONDITION APPROACHING THEIR NATURAL STATE. THE MOST DIRECT APPROACH TO ACHIEVING

this goal is to remove dams that impound rivers and, as a result, block the free migrations of fish and other aquatic species. Dam removal on the Baraboo River has opened the door for an opportunity to conduct research on the effects dams have on aquatic ecosystems and the impending impacts of their removal.

In the world of dam removal, Wisconsin has displayed tremendous leadership. Even before statehood, the territorial government created a law that required a means for fish passage on any new dam constructed. At that time, however, technologies were generally ineffective for fish passage. Over the years there was increasing development and prosperity, yet little advancement in technology or interest in fish passage.

One hundred to 150 years ago, most of Wisconsin's smaller dams were built to provide power for various milling operations. As dependence on electricity increased, many small dams were converted to hydropower generation. In time, these small dams became inefficient or costly. In some cases, communities only maintained the dams for their historic or aesthetic value, or owners simply abandoned them rather than incur expenses for taxes and liability.

Regardless of the disposition of old dams, time and gravity take their toll deteriorating dams to a point where safety becomes a concern. It is the charge of the DNR Dam Safety Program to periodically conduct safety inspections and, when dams are judged to be in unsafe condition, to require corrective actions and recommend appropriate remedial alternatives. Some dam owners are readily agreeable to dam removal rather than incur the cost of repair.

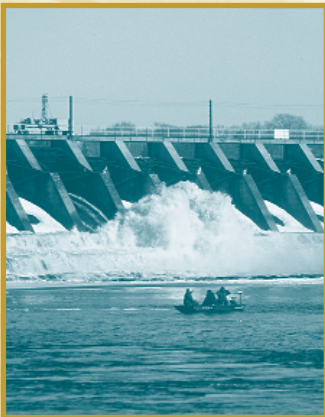
Dam removals have been conducted on the Baraboo River at several sites over the past 50 years. But as recently as the mid 1990s, four dams (in varying states of deterioration) still remained to fragment the main stem of the river blocking fish movements and migrations. As a result, concerned citizens groups and governmental agencies partnered to address the situation. Leadership fell to the DNR's South Central Region and principle partners included Science Services, UW-Madison's Center for Limnology, UW-Stevens Point's Wisconsin Cooperative Fishery Research Unit, River Alliance of Wisconsin, Sand County Foundation, Sauk County Lands Conservation Department, and the municipal governments

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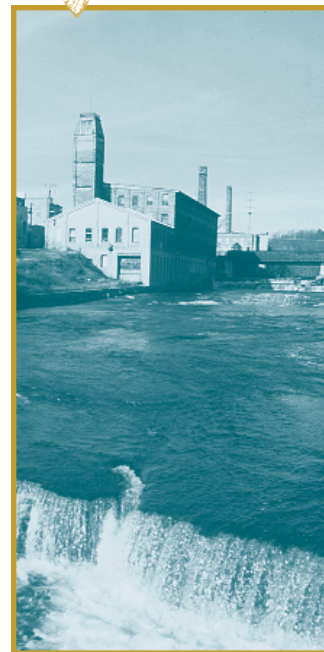


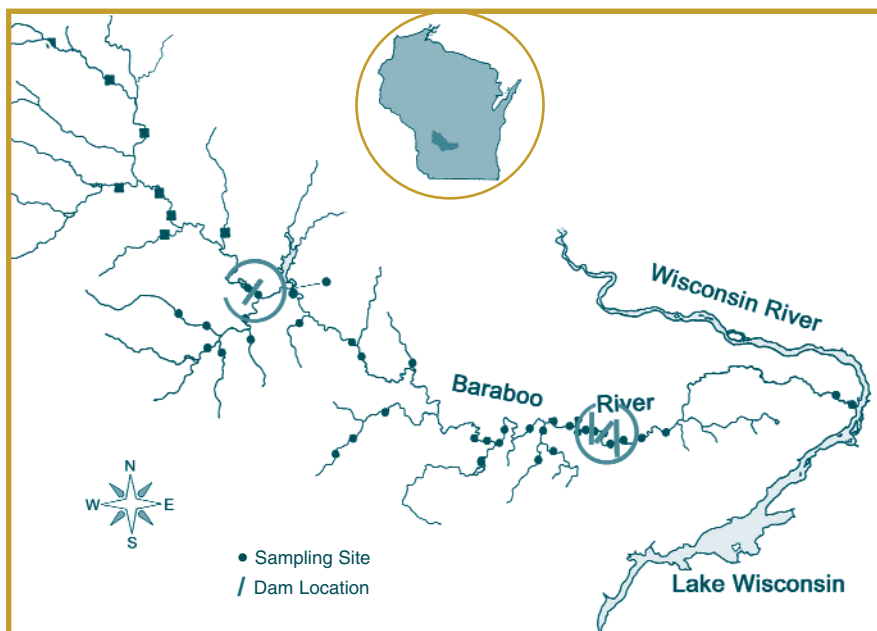
of Baraboo and LaValle. The end result was that all four of the remaining dams were slated for removal between 1997 and 2002.

Researchers recognized that these last remaining dams could provide an excellent opportunity to study the effects of dams and their removal. Immediately, Dr. Emily Stanley (UW Center for Limnology) began sediment transport studies and David Marshall (DNR South Central Region) began work on the impacts of dams and their removal on aquatic macroinvertebrate populations. Tom Pellett, a Science Services researcher, headed a team to study the impacts of dams and dam removal on fish community structure and fish migrations in the Baraboo River.

Fieldwork for Tom's research project began in 1999 and will continue through 2005. The project focuses on two dynamics of fish ecology in rivers: community structure and population migrations. To evaluate changes in community structure they are comparing pre- and post-dam removal Index of Biotic Integrity (IBI) scores. The IBI measures the health of the river using fish species, guild presence/absence, and biomass. Electrofishing gear is used to collect fish during the summer at pre-determined sample sites during each year of the study. To determine which fish species are migratory and the extent of their pre- and post-dam removal movements, researchers are using electrofishing gear and hoop nets to capture fish at various sites along the Baraboo River and from adjacent waters of the Wisconsin River. Adults of 18 target species are marked with uniquely numbered tags and released at the site of capture. Seasonal movements and migrations are being evaluated by comparing marking locations to recapture locations and comparing data from anglers that report catching tagged fish.

Science Services researcher John Lyons and fisheries manager Tim Larson have previously collected fisheries data above and below three dams in





Removal of the final 4 dams on the main stem of the Baraboo River (3 in Baraboo and 1 in La Valle) between 1997 and 2002 has had a tremendous impact on the fish species. Sampling at sites along the river pre- and post-dam removal have found that habitat has improved, fish are able to migrate freely, and anglers are catching more species of fish than ever before.

the city of Baraboo (the fourth dam is in the city of LaValle) prior to the removal of the Waterworks Dam in 1998. They found that there were no resultant changes in terms of fish migration, since the Waterworks Dam was located in the middle of the three dams, and the lower (Linen Mill) and upper (Oak Street) dams were still in place. However, they did find that the habitat upstream from the Waterworks dam site improved dramatically within 18 months of its removal!

All the dams on the main stem of the Baraboo have been removed, freeing the river of obstructions to fish migration. To date, we have completed one year of post-dam removal studies. Since all the dams have been removed, a number of fish species have moved upriver beyond the former barriers. Fish that were tagged below the dams have been found up to 50 miles farther upriver. Anglers are making comments such as, "I've fished up here for 40 years and I've never seen a sheepshead, but now I'm catching them!" Eleven fish species (including lake sturgeon) that were rarely or never seen upriver from the dams prior to the removals are now being found there. Other fish that were rarely seen above the Linen Mill Dam now spawn there in substantial numbers. Nearly all the larger native species of fish in the Baraboo have been

found to be migratory. Catfish even "home" to the same spawning and feeding grounds every year before migrating to their over-wintering habitats in the Wisconsin or Baraboo rivers. One particularly interesting fish is the emerald shiner. Only three to four inches long, adult shiners were never able to get over the dams. That these tiny fish had been extirpated above the dams was well known. Now that the dams are gone, researchers are observing large schools of them as far as 70-80 miles upriver! Removal of the dams may also have a positive impact on the gene pool of some fish populations, which may correlate with increased adaptability potential and species fitness.

Studying the impacts of dams and dam removal on fish contributes to our understanding of the ecology of the river system, fish behavior, and the importance of fish being able to move throughout the system. The results of this study provide scientific data supporting the removal of dams and development of fish passage projects as beneficial to the surrounding ecosystem. The findings may have a huge significance in fish management and restoration of fish species. Findings from this research on dam removal will benefit resource managers far beyond the borders of Wisconsin as they too struggle with some of the same resource and economic issues. ●

Concrete Effects ON STREAMS

THE RESULTS OF A STUDY EXAMINING THE EFFECTS OF URBAN LAND USE ON STREAM HABITAT AND FISH HAVE ATTRACTED A LOT OF ATTENTION AND STIMULATED MANY DISCUSSIONS ON HOW WE CAN DEVELOP LAND

while maintaining healthy stream ecosystems. This particular study compared historical data collected twenty years ago with data currently collected from stream watersheds (the area of land that drains into a river) with different levels of urban development. The results of this project will produce a tool for DNR staff and others to predict stream health at any given level of urban development. Armed with this information, Watershed Management staff, urban and regional planners, builders and developers, researchers, local government officials, and concerned citizens will be better prepared to make decisions about how much development a watershed area can withstand while still maintaining the health of the streams. As Wisconsin is growing, expanding, and developing, information that will help us approach progress wisely and in a way that protects the quality of our water resources is absolutely crucial.

Lizhu Wang, a Science Services watershed ecologist leading this project, explained that elements of the research emerged from questions, such as:

- Can urban land use that does not release known source pollutants still degrade streams?
- What are the indicators of degraded streams and how are they linked to urban development?
- At what level of urban development can stream quality be maintained?
- At what level of urban development can cold-water streams no longer support trout fisheries?
- Do stream buffers help ease the impacts of urban development?
- Can the level of impact that planned urban development has be predicted?

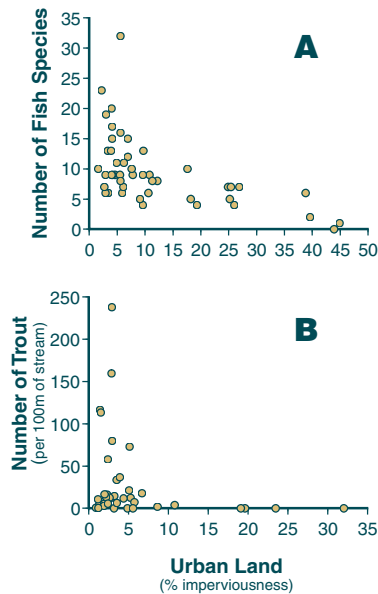
So what's wrong with development? Urban land use modifies the land surface and produces both changes in the types and magnitude of runoff (i.e. the water that runs off the land surface during and after a rain). Urban development also clears vegetation, compacts soil, ditches and drains wetlands, and covers land surface with roofs, parking lots, sidewalks, and roads. These man-made surfaces do not allow rainfall to be soaked into the ground, but instead create huge amounts of surface runoff. Large amounts of runoff increase flood frequency and severity during rain events, and decrease flow in stream channels after the rain. In addition, surface runoff brings into the streams any materials that have accumulated on the land surface (e.g., oil, road salt, organic particles, lawn herbicides, pesticides, etc.). The process of urban development erodes stream banks, changes stream bottom composition, reduces dissolved oxygen levels, and ultimately changes water quality. Since urban development affects all components of a stream ecosystem and it is economically unfeasible to measure

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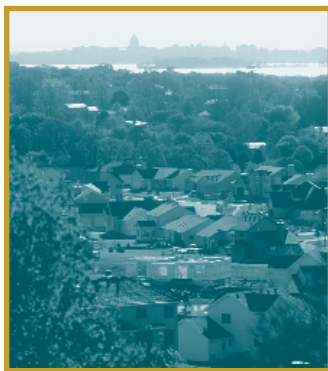




concrete effects



Relationship between watershed urban development (% imperviousness) and fish abundance. (A) A greater number of fish species indicates a better fish community in warmwater streams. (B) A greater abundance of trout indicates a better fishery.



every single change that can result from urbanization, this project focuses on in-stream physical habitat, fish, and insects that are good indicators of the overall effect of urban development on streams.

Wang, and fellow researchers John Lyons and Paul Kanehl, sampled streams in southern Wisconsin to ascertain how urban land use in a watershed affects water quality. Use of digital satellite data helped determine the portions of the land used for urban development in the targeted watersheds and riparian areas (the area along the edge of water). Information on stream habitat and fish cover was collected. Fish were sampled by electrofishing and insects were sampled using a kick net. Current fish data was compared to historic data to relate changes in the fish community to changes in urban land use. Mathematical models were developed to determine the point at which the level of growth will be so great that streams will no longer support healthy trout populations. They looked at the effects buffers have on stream health and they compared a fish health index for the fish community with the amount of urban development up to 1 mile from the stream.

The researchers found that urban land use strongly affects stream quality, even with low levels of suburban development severely damaging streams. The study also revealed that an increase in urban land use is strongly linked to a decrease in the number of fish species and the base flow of the stream. The best measure for determining the percent of urban development and predicting the health of the stream in an area is to identify the amount of *connected* impervious surface in the watershed. The term 'impervious surface' refers to any surface that does not allow rainwater to soak into the ground. Connected impervious surface levels between 7% and 12% represent a threshold region where minor changes in urbanization could result in major changes in stream condition. When a watershed has impervious surface levels greater than 12%, streams can no longer support a trout population. Land use in riparian areas has a disproportionate influence on stream health, despite the relatively small size of a riparian area compared to the size of a watershed. That is, a small amount of land use change in a riparian area will have a large impact on a stream. As a result, urban development that minimizes the amount of impervious surface and establishes *undeveloped* riparian areas along streams will have less impact on stream health than conventional types of development.

This project has contributed to the protection of our urban streams. The research has already helped convince people to address problems related to development and the results will help us define what needs to be done. The data and models generated from this study have been widely used in other parts of the U.S. and around the world! ●